

Interagency Memorandum Information

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Division: Office of Legacy Management

Funds-out/disbursement

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Project Title: Method to Evaluate Maximum Post-Restoration Contaminant Concentrations in ISR Well fields to Prevent Breach of UIC Aquifer Exemption Boundary and Protect USDWs Downgradient from ISR Well fields Using Core Data, Injection/Recovery Field Tests and Reactive Transport Modeling

Abstract: This Inter-Agency Agreement (IA) is being established to support EPA's groundwater research program. The work conducted under the agreement will help support efforts underway in EPA's Underground Injection Control (UIC) Program, which is currently preparing a draft permit decision for the Powertech (USA) Incorporated (Powertech) proposed Dewey Burdock uranium in-situ recovery (ISR) site in southwest South Dakota. The EPA, Region 8, Underground Injection Control (UIC) Program is also currently preparing a draft aquifer exemption decision that, if approved, would allow lixiviant injected through Class III injection wells to mobilize uranium within ore-bearing aquifers. At active ISR wellfields, after the ISR process is complete, the NRC (or Agreement State) license and State mining permit conditions require the groundwater in the wellfield to be restored to pre-mining conditions. Often, Alternative Concentration Limits must be established when pre-mining conditions cannot be regained for some constituents. The link between aquifer restoration and the UIC Program is that after aquifer restoration is complete and the natural groundwater gradient is re-established, it is a violation of UIC regulations if contaminants cross the aquifer exemption boundary. The Region 8 UIC Program is seeking continued support from the EPA Office of Research and Development and other partners, including the Department of Energy (DOE) and the Los Alamos National Laboratory (LANL) in establishing sound, science-based, criteria and strategies to support aquifer exemption evaluation and decision-making associated with UIC Class III permitting. Such support will help ensure long-term protection of groundwater resources outside the aquifer exemption boundary. This 2014 project builds upon work completed under a 2010 Regional Applied Research Effort (RARE) project in a two-phased approach: 1) finalize and document work performed to evaluate and model the potential for oxidized solid phase to remove uranium from groundwater through sorption mechanisms at the Dewey Burdock site and 2) evaluate the effects of downgradient geochemistry/mineralogy on uranium-bearing groundwater by conducting an injection/recovery field test. This continuing project work will integrate downgradient aquifer geochemistry/mineralogy and field testing at ISR wellfields to establish a state-of-the-art reactive transport methodology. This integrated methodology will be used in determining maximum concentrations of contaminants (post-restoration) that can be mitigated by the aquifer geochemistry to prevent any future non-compliance at the aquifer exemption boundary. This work is also pertinent to the revision of the 40 CFR Part 192 regulations which apply to uranium ISR site restoration, and which must be adopted by the Nuclear Regulatory Commission, their Agreement States, and the Department of Energy. An important aspect in proposing new standards is evaluating potential impacts to groundwater. The work proposed under this project has recently been identified by the EPA Headquarters Office of Groundwater and Drinking Water (OGWDW) as being a key research need as part of a national effort to re-examine how EPA evaluates aquifer exemption proposals.

1. Background: The uranium ISR process extracts uranium by injecting a lixiviant into an ISR wellfield to dissolve uranium from ore deposits located within the ore-bearing aquifer. This process changes the pre-existing aquifer geochemistry and mobilizes uranium into a solution that flows to recovery wells. The EPA UIC Program is evaluating a proposed aquifer

exemption boundary surrounding ISR wellfields beyond which any ISR-related changes in groundwater quality would violate UIC permit conditions. The aquifer exemption decision has a direct impact on Safe and Sustainable Groundwater Resources. Although the groundwater restoration process is intended to return the wellfield groundwater to pre-mining conditions, this is often not possible for all constituents mobilized by the lixiviant¹. Alternative Concentration Limits must then be established as groundwater restoration goals for certain constituents. However, downgradient aquifer geochemistry/mineralogy has only recently been examined to determine if groundwater contaminants will be removed from solution through rock/water interactions before reaching the aquifer exemption boundary.

Under a 2010 RARE project, USGS developed a general conceptual model and 1D/2D reactive transport models (groundwater flow and geochemistry) for uranium roll-front formation, current groundwater conditions, and simulations of uranium ISR, restoration, and long-term, downgradient transport based on pre-mining data. This 2014 project will involve 1) the completion of a study examining the uranium adsorption capacity of oxidized host rock downgradient of a uranium roll front deposit and 2) an injection/recovery field test to examine the effect of reduced host rock on high uranium groundwater.

How Project Will Provide New Knowledge, Data, and Tools Needed: Part 1 of this project will provide a tool to evaluate the natural attenuation capacity of the oxidized solid phase potential to remove uranium from groundwater through sorption mechanisms. The study results will be documented in a peer-reviewed journal article providing summaries of

1. data needs for modeling,
2. results of batch studies performed to quantify uranium sorption to oxidized core,
3. iron extraction results and modeling uranium sorption to iron only, and
4. results of a generic composite surface complexation model using data from the batch studies in which potential for sorption to any surface is taken into account.

Part 2 of this project will involve a field test examining the impact on water quality of high-uranium groundwater as it flows through solid-phase conditions equivalent to downgradient, unmined, reduced-zone host rock. Laboratory column and batch tests have been performed simulating this interaction; a field test is the next logical step in the evaluation of this natural attenuation process. The natural attenuation field test is intended to obtain estimates of attenuation capacity in the aquifer downgradient of an un-mined ore body and provide information on the attenuation mechanisms. Results from the field test will be evaluated using reactive transport modeling in an FY2015 component of this work (will be a separate statement of work). This field test provides a unique opportunity for DOE LM to better understand the natural attenuation of uranium in reducing zones. DOE LM interests are at mill sites where uranium plumes encounter reducing zones, which can either attenuate and/or create plume persistence issues. A field test where uranium contaminated water is injected into an “uncontaminated zone” will provide very valuable information on uranium transport in groundwater in reducing zones. Such a test would not be allowed anywhere else except in an ISR unit that is about to be mined, as any changes in the geochemistry will soon be “overprinted” by the ISR process.

2. Project History: Under a 2010 RARE project, the USGS determined that downgradient solid-phase data (from ore zone core) are critical for developing and calibrating reactive transport simulations of potential uranium movement (and other dissolved constituents) away from uranium in-situ recovery sites.

The Region 8, UIC Program has been working closely with the South Dakota Department of Environment and Natural Resources and the Nuclear Regulatory Commission, building federal and state partnerships during the technical evaluation of Powertech’s Dewey Burdock ISR applications submitted to each respective agency. The 2010 RARE project

¹ Hall, S, 2009, Groundwater Restoration at Uranium In-Situ Recovery Mines, South Texas Coastal Plain: U.S. Geological Survey, Open-File Report 2009–1143, 32 p.

has facilitated this partnership-building effort; this project work will strengthen these existing partnerships. The Region 8, UIC Program is currently engaged in providing informational web conferences related to the tribal consultation process required under the National Historic Preservation Act and the EPA Tribal Consultation Policy. Work proposed for this project will provide technical support to address questions from the tribes and other members of the general public who are asking about impacts to groundwater from uranium ISR sites. In addition, this work will provide technical support to the Region 8 UIC Program, the NRC and the SD DENR as they move forward with addressing public concerns about the uncertainties of post-ISR groundwater restoration.

3. Research Objectives: This project proposes strategies for addressing the following questions:

- a) Given possible groundwater quality scenarios at the end of ISR restoration efforts, what reactions could take place down gradient of the uranium recovery zones?
- b) What is the solid-phase geochemistry/mineralogy down gradient from the recovery zones and how does this geochemistry influence #1?
- c) With the results from a) and b), what is the prediction of long-term fate and transport of any groundwater contaminants away from the uranium recovery zones?

Recently there has been increased scrutiny of the EPA's aquifer exemption decision-making process across the Regions and how aquifer exemptions should be determined in order to maintain safe and sustainable groundwater resources. A methodology is needed to better inform the EPA aquifer exemption evaluation process. This project will result in development and verification of a methodology to 1) evaluate whether well field groundwater restoration targets will prevent changes in groundwater quality downgradient of the aquifer exemption boundary, and 2) evaluate downgradient solid-phase aquifer geochemistry/mineralogy and its potential for mitigating groundwater quality changes downgradient of the ISR well field before the aquifer exemption boundary is reached.

4. Research Approach: This project will be a collaborative effort involving partnerships with the Colorado State University, the South Dakota School of Mines, the DOE Office of Legacy Management, LANL, the EPA Office of Research and Development and the Region 8 Underground Injection Control Program. Cameco Resources' Smith Ranch-Highland uranium ISR mine, located 17 miles north of Glenrock, Wyoming, provided core from three locations within two well fields. Core was drilled within the uranium roll front ore zone, upgradient and downgradient from the ore zone in a well field that was previously mined, but not restored (Mine Unit 4) and a well field that had not yet gone into production at the time the core was collected (Mine Unit 3 extension). Cameco Resources is providing the use of two production wells in another pre-mining well field (Mine Unit 7) that will serve as a proxy site for downgradient geochemical conditions, with the assumption being that the geochemical conditions in the pre-mining/pre-lixiviant ore zone are nearly identical to the geochemical conditions that will exist downgradient of the ore zone after ISR mining. Laboratory analysis of core samples from the ISR well fields is being conducted by the Colorado State University in part to evaluate the validity of this assumption. LANL is conducting laboratory column testing to evaluate the uranium attenuation capacity of a subset of this core. The South Dakota School of Mines conducted batch adsorption experiments to determine adsorption isotherm curves. The South Dakota School of Mines and the USGS also performed reactive transport modeling using the laboratory bench scale results.

The field work that will be conducted under this project involves injecting 1000-2000 gallons of groundwater high in uranium concentrations from Mine Unit 4 into two production wells in Mine Unit 7. The uranium concentrations in the MU-4 water should be about 3 orders of magnitude higher (~60 mg/L) than the MU-7 water (~20-50 µg/L). The MU-4 water will be injected as quickly as possible and transported with as little headspace as possible after collection to minimize the introduction of oxygen to the ore zone and thus better simulate an oxygen-depleted water migrating downgradient from an ore zone. The injection of the 1000-2000 gallons of water from MU-4 will be followed by

injection of a few thousand gallons of water from MU-7 (directly plumbed from a nearby production well to the well being used for injection). This “chase” water will ensure that the water from MU-4 is “pushed” into the aquifer with representative water and does not linger in the borehole.

Both of the test wells will eventually be pumped back to recover the injected solutions, with one well allowed to sit idle for a few weeks before pumping, and the other allowed to sit idle a few months before pumping. The time range for recovery on injected water will provide interrogation of attenuation kinetics. In both cases, the injected MU-4 water will be spiked with bromide and a fluorinated benzoate tracers to allow comparison of the responses of these conservative tracers with that of uranium to deduce uranium attenuation parameters from the tests. Other contaminants may be analyzed subject to budget and time constraints.

In addition to uranium concentrations, uranium isotope ratios will also be measured in the injection water from MU-4 and in water samples collected during the pumping of the production wells, which will provide insights into whether the observed attenuation is due to adsorption or reduction or some combination of these two processes which have different isotopic signatures. The responses of the bromide and the fluorinated benzoate will also be compared to obtain estimates of diffusive mass transfer rates and relative volumes of flowing and stagnant water in the aquifer. Because these tracer anions have different molecular sizes, they have different diffusion coefficients for mass transfer between flowing and stagnant water in aquifer.

Reactive transport modeling will integrate the lab and field test results to provide a state-of-the-art process for predicting contaminant transport away from uranium ISR sites. These final efforts will be published as peer-reviewed journal articles and will be part of a separate statement of work for FY2015.

5. Research Results and Products

A. New data	The effects of downgradient geochemistry/mineralogy on uranium-bearing groundwater will be evaluated by an injection/recovery field test. This information is key to predicting future groundwater quality as restoration fluids in the recovery zones begin to contact the downgradient solid phase.
B. Tools	Reactive transport modeling is a tool for evaluating changes in groundwater quality as it interacts with the solid phase. This project will finalize and document work performed to evaluate and model the potential for oxidized solid phase to remove uranium from groundwater through sorption mechanisms at the Dewey Burdock site. Modeling work will also be used to evaluate the changes in water quality of the recovered injectate from the field test at the Smith-Ranch Highlands site. Laboratory column testing will be used to confirm potential geochemical reactions that will be used in the reactive transport model and improve the predictive power of this tool.
C. Regulatory decision support and Program support	2014 project work will support continued efforts of EPA, NRC and DENR in the technical evaluation of the uranium ISR restoration requirements and impacts to downgradient USDWs. The 2014 focus will be assessment of long-term groundwater quality downgradient of the uranium ISR well fields. Results will help evaluate the levels of restoration necessary to meet EPA groundwater quality requirements at the compliance points. This information will also be used in addressing concerns identified during the draft permit and aquifer exemption public review process.
D. Enforcement support	Reactive transport modeling will provide information on data collection and monitoring requirements to include in UIC permits to ensure protection of USDWs. Modeling results will provide insight into the type of monitoring and timeframes needed to verify compliance with UIC permit conditions.
E. Reports F. Models G. Scientific Articles	2014 project work will be documented and communicated in presentations at technical conferences, scientific reports, and deliverables to the EPA in order to assure effective research communication planning. Deliverables will include 1) a report on laboratory experiments and data needs to support reactive transport modeling of uranium sorption and precipitation, 2) results of an injection/recovery

	field study simulating the natural attenuation capacity of reduced host rock downgradient from an ISR well field and 3) a report on predictive reactive transport modeling at the EPA compliance points, with information on appropriate groundwater monitoring strategies and time frames.
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6. Proposed FY14 Budget: \$ 125,000

FY14 project work will focus on the completion of oxidized zone adsorption studies and the injection/recovery field test in Mine Unit 7. The data collection effort that was originally included in the proposal has been addressed by the cooperating entities discussed above. Salaries will partially reimburse DOE for contractor hours, as appropriate. The DOE will commit remaining funds to support the injection/recovery field test conducted by LANL at the Cameco Resources Smith Ranch-Highlands Mine Unit 7. Project work will continue into FY15 to complete the modeling effort and finalize deliverables.

Task	Cost
DOE overhead	\$ 3,750
Salary, modeling work	30,000.00
Field test support	91,250.00
total	[=SUM(ABOVE)]

7. Project Timeline

March –April 2014	Identify funding vehicle; initiate interagency agreement. The Region 8 Lead Technical Contact will work closely with the ORD Principal Investigator to facilitate communication between ORD and DOE while the interagency agreement is developed and finalized.
April - June 2014	1) Initiate project by finalizing Project Work Plan and Quality Assurance Project Plan for review by ORD Principal Investigator. The Region 8 Lead Technical Contact will work closely with the ORD Principal Investigator to jointly manage project activities, goals, and completion of research products. 2) Complete final efforts and draft journal article on evaluating and modeling the potential for oxidized solid phase to remove uranium from groundwater through sorption mechanisms (Dewey Burdock). 3) Conduct injection/recovery field testing at Cameco Resources Smith Ranch-Highlands Mine Unit 7.4) Data analysis from short recovery time groundwater samples from injection/recovery field test. 5) Data interpretation and preliminary final report for injection/recovery field test.
July 2014 – Sept 2014	Data collection and analysis for longer recovery time groundwater samples from injection/recovery field test. Assemble the data from column and batch tests to begin setting up predictive reactive transport models (Smith Ranch Highlands).
FY15 Work	Interagency agreement will include option to extend project an additional year in order to integrate field and lab test into a reactive transport model at the Smith Ranch Highlands site and complete deliverables.